

Thesis/
Reports
Del Sordo,
D.

IDENTIFYING AND CLASSIFYING
WILDERNESS RIPARIAN AND WETLAND
VEGETATION STRUCTURE USING A
GEOGRAPHIC INFORMATION SYSTEM

IDENTIFICATION AND CLASSIFICATION OF WILDERNESS RIPARIAN AND WETLAND VEGETATION STRUCTURE USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEMS

Final Report

7 April 1995

David DelSordo

School of Forestry, University of Montana

Introduction

This research study has been developed cooperatively between the University of Montana, School of Forestry and the USFS Aldo Leopold Wilderness Research Institute. This is a report on the initial phase of the study. The objective of this study was to develop and test a methodology using Remote Sensing (RS) and Geographic Information Systems (GIS) to improve the identification, classification, mapping, and monitoring of wilderness riparian and wetland areas. Our goal is to provide wilderness managers (and other resource managers) with techniques for quantifying the current distribution and structure of riparian and wetland ecosystems. We hope to contribute to an improvement in the ability to monitor the impacts of recreation use (and other disturbances) on an important component of wilderness wildlife habitat.

Our plan is to explore the utility of describing riparian and wetland areas by their vegetative structural class and associated landform. Examples of structural class are tall, woody riparian or herbaceous riparian. Landform examples are cirque floors or alluvial basins. Therefore, a tall, woody riparian/cirque floor type would be different than a tall, woody riparian/alluvial basin type or an herbaceous riparian/cirque floor type. This method will create a taxonomy of riparian and wetland types that can be identified in the field or from the analysis of digital data.

This project as completed primarily involved the assembly, formatting, and development of digital data to be used in support of the stratification of riparian areas into classes based upon geomorphology.

Study Area

Riparian and wetland areas in the Anaconda-Pintlar Wilderness (AP) were studied in this project. The AP covers over 63,000 ha in southwestern Montana along the Continental Divide in the Beaverhead, Bitterroot, and Deer Lodge National Forests (Figure 1). Elevations range from 1,650 m along the East Fork of the Bitterroot River to 3,290 m atop West Goat Peak. Riparian and wetland areas include the shores and

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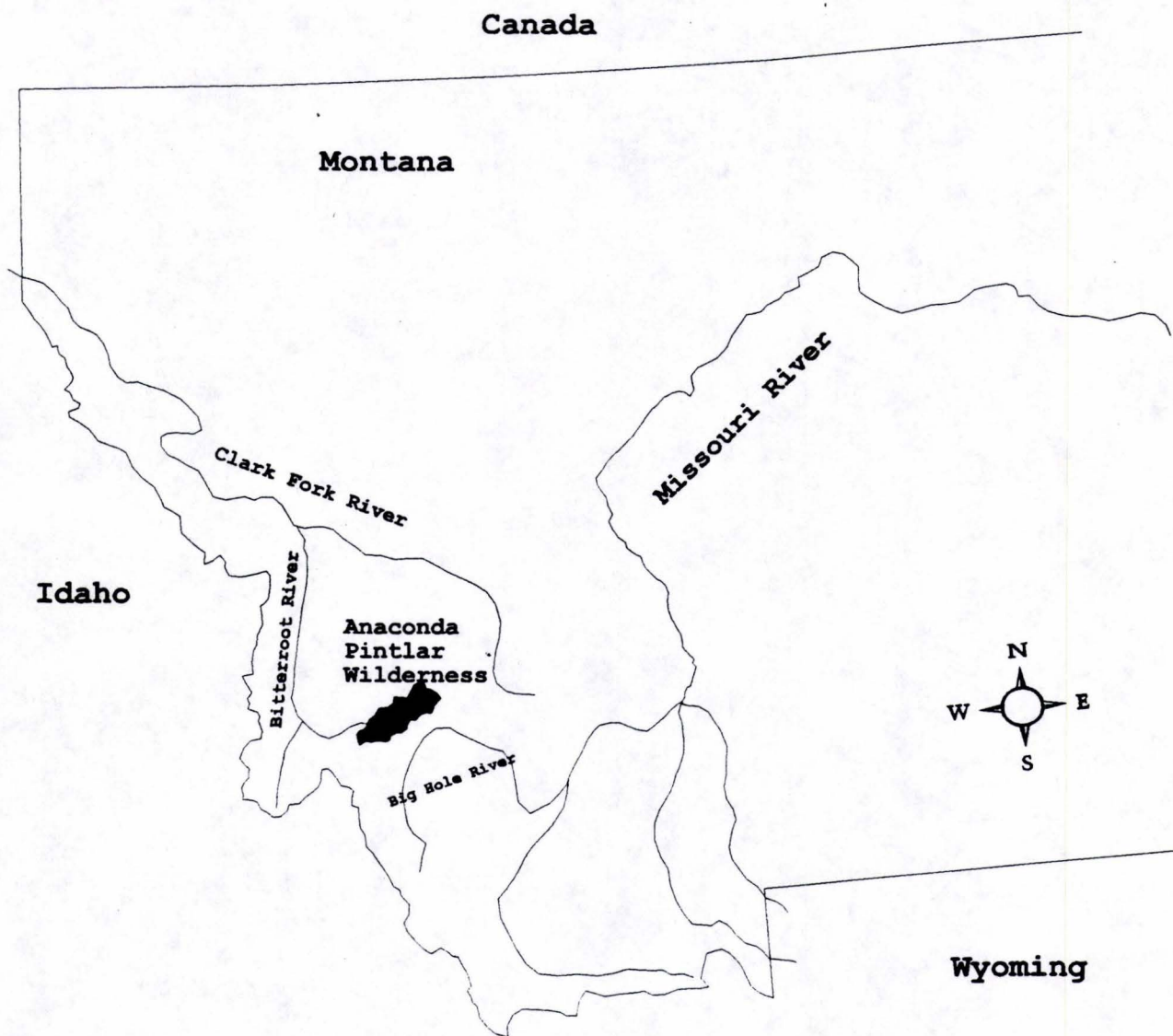


Figure 1. The Location of the Anaconda Pintlar Wilderness in Western Montana.

banks of streams, marshes, alpine lakes, and wet meadows. These areas are suspected to be important to a wide variety of wildlife and attractive to people for recreational uses. The study area for this initial work was the drainages of Seymour Creek and the East Fork of La Marche Creek in the eastern portion of the AP (Figure 2). This study area is covered by the US Geological Survey (USGS) 7.5' quad sheets: Lower Seymour Lake, Mount Evans, Storm Lake, and Long Peak.

Methods

The initial task of this project was to begin the collection and integration of the available digital data for the study area. This digital data was obtained from a number of sources and in a number of formats. The primary GIS package used for my work on this project was PAMAP. The GIS methods described here are typical of those that would be utilized in other GIS packages. The description of these methods is intended to highlight the procedures used when working with digital data. It is not my intention nor is it possible to offer the reader a cookbook approach to working with digital cartographic data. In the narrative below, the procedures in each section will be numbered.

All mapping was done at 1:24,000 scale. The initial stratification of riparian types was based upon landform and stream gradient. The hydrography data was supplied by the USFS Northern Region Cartography Office as digital cartographic feature files. In this case, hydrography refers to the vector elements that represent the streams and lakes of the study area. The slope and elevation coverages in the GIS were used to break the streams into four classes: 0-5% slope, 5.1-10%, 10.1-15%, and >15% slope. The landform membership of each reach was also identified.

Hydrography

The hydrography was supplied by the USFS Northern Region Cartography Office as digital cartographic feature files. This data was in the Albers Equal Area projection in a cartographic coordinate system rather than geographic coordinates. In a cartographic coordinate system, the south west corner of the map is set as the origin with coordinates of 0,0, while in a geographic coordinate system the coordinates of the origin relate to a real world coordinate such as 114:45:00° W Longitude, 46:45:00° N Latitude. PAMAP expects import data to be in the Universal Transverse Mercator (UTM) projection and geographic coordinates. As a result, PAMAP brought the data into the import map on the equator (0° Longitude).

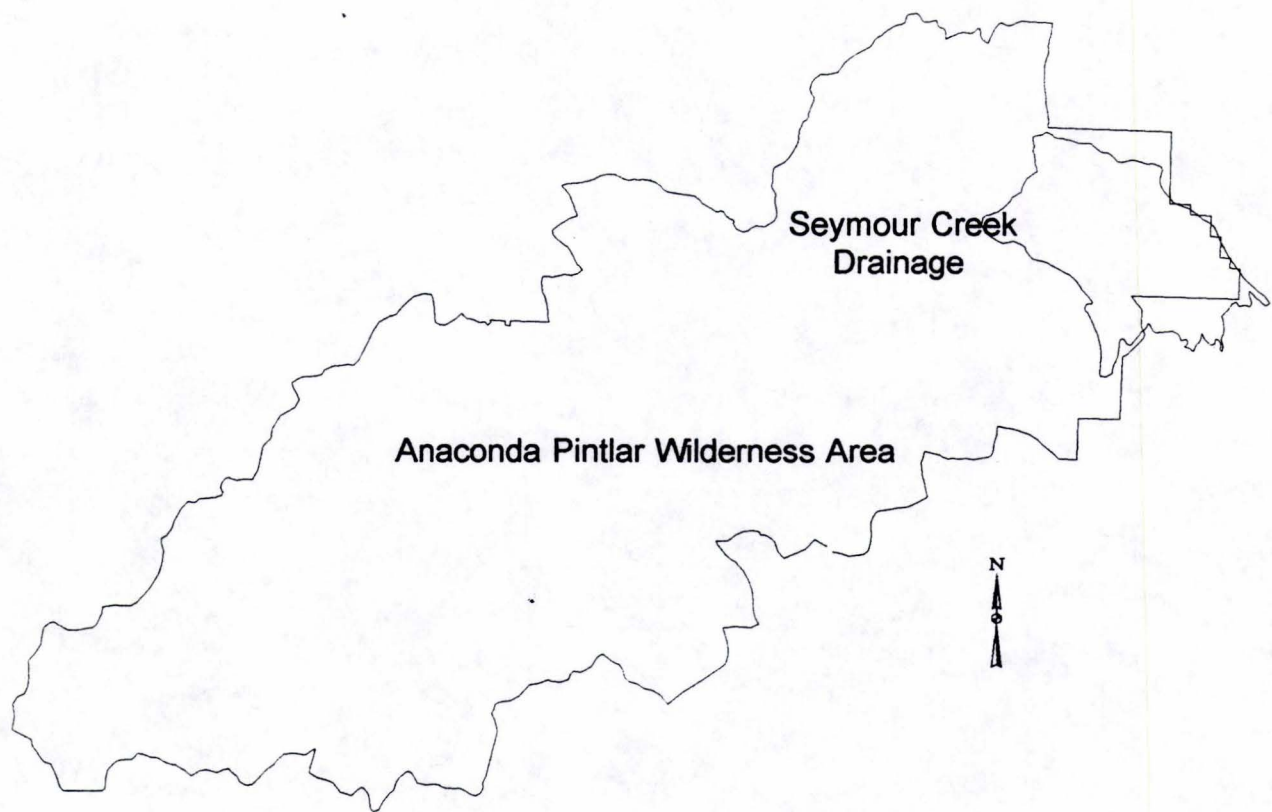


Figure 2. The Location of the Seymour Creek Study Area within the Anaconda Pintlar Wilderness Area.

In order to bring the data into the correct coordinate system:

- 1) I created a map in UTM Zone 12 coordinates that stretched from the equator to N 47° latitude.
- 2) I merged the desired data from the import map to the new UTM map.
- 3) Next, I created a series of paired old and new control points for rubber sheeting. I used the grid representing the corners of the 7.5' quads as the control points. This grid existed as a part of the original hydrography vectors. I used PAMAP's cartographic rubber sheeting utility to transform the data to the real world location. The transformation of vector elements is based on the paired control points - one to define the existing (old) location, the second to define the desired (new) location (EPS 1994).
- 4) The transformed data was then merged into a target map that matched the extent of the AP.
- 5) I sampled the location of the quad corners in the resulting target map and compared the results to the actual locations of these corners on the 7.5' quads. The difference ranged from 4 - 16 m. This error is compatible with national map accuracy standards for 1:24,000 scale.
- 6) I created a subset of the AP map for the Seymour Creek drainage and imported the data for each coverage into that map for display and analysis of the study area.

This procedure is not the ideal way to handle or import data for spatial analysis. However, it was necessary for me to produce an initial stratification of the stream segments for sampling during the 1994 field season. The need to perform this radical rubber sheeting of the data could be avoided by insuring that the data is exported from the source in a geographic coordinate system.

Once the hydrography vectors were imported into the GIS, I prepared them for network analysis.

- 7) This required that the hydrography vectors be cleaned to eliminate duplicate strings and to create nodes at vector junctions.
- 8) The cleaned vectors were formed into a network with topological structure and an associated database for each network segment. I allowed the program to create vector segments based upon their topology. In this case, the network formation created 90 separate stream segments or reaches. This number is influenced by the procedures and decisions made by the analysts who originally digitized the hydrography layer.
- 9) I overlaid the hydrography vector database on the elevation level. This operation updated the vector database with statistics from the digital elevation model (DEM). These statistics included the minimum, mean, and maximum elevation; planimetric and slope distance; and percent slope for each stream segment.
- 10) I also overlaid the hydrography vector database on the landform level. This operation updated the vector database with the relevant landform for each segment.

- 11) Finally, I exported the vector database to Foxpro database management system for display and analysis.

Digital Elevation Model

A DEM was supplied by the USFS for each quad in the AP. These DEMs were edited in Line Trace + and did not have carriage returns at the end of each line. The PAMAP DEM translator expects carriage returns and could not read these USFS DEMs. This situation required additional steps to prepare the DEMs for import into PAMAP. A program, DEM2DAT, is available from the US Bureau of Land Management. This program reformats DEM files into an x,y,z file compatible with PAMAP Topographer's ASCII import utility. The program, DEM2DAT, is available at an anonymous FTP site, DSC.BLM.GOV, on the Internet.

Once the DEMs were imported into PAMAP, the Topographer module successfully edge matched the DEM for each quad and built the elevation, slope, aspect, and contour layers for the entire AP. This topographic data was used to classify the stream reaches by their gradient (Figure 3). The steps used in processing the DEMs are outlined below.

- 12) Run program DEM2DAT on the DEM files for each quad.
- 13) Use PAMAP Topographer ASCII import function to read in the DEM files.
- 14) Use Topographer Build DEM function to create one DEM surface cover for the entire AP and for Seymour Creek (Figure 4).
- 15) Use Topographer to derive slope, aspect, and contour covers of the AP.

Landform

Landtype mapping for the Seymour Creek Drainage has been completed by the Beaverhead National Forest. The landtype polygons associated with the watersheds were used to define the extent of the study area.

- 16) These polygons were digitized as a layer in the GIS from USGS 7.5' quads provided by the Beaverhead National Forest .
- 17) The landtypes were then aggregated to their associated landform following the taxonomy of Holdorf and Donahue (1990).

Vegetation Sampling

Field investigations were conducted by the USFS Aldo Leopold Wilderness Research Institute to establish the range of variation in the vegetation of the riparian and wetland areas. An important objective of the field sampling was to collect data on the

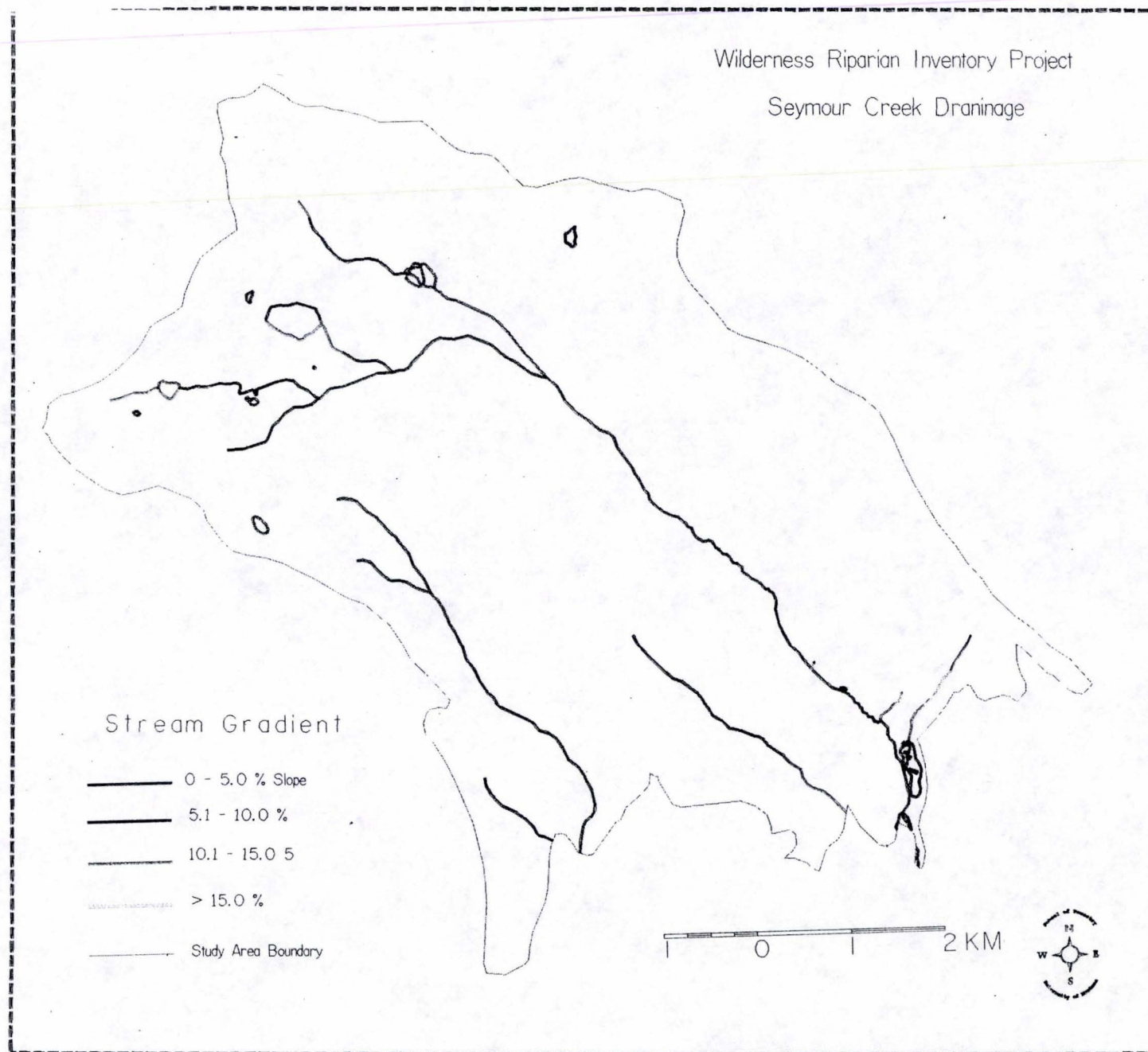


Figure 3. The Stream Reaches Classified by their Gradient.

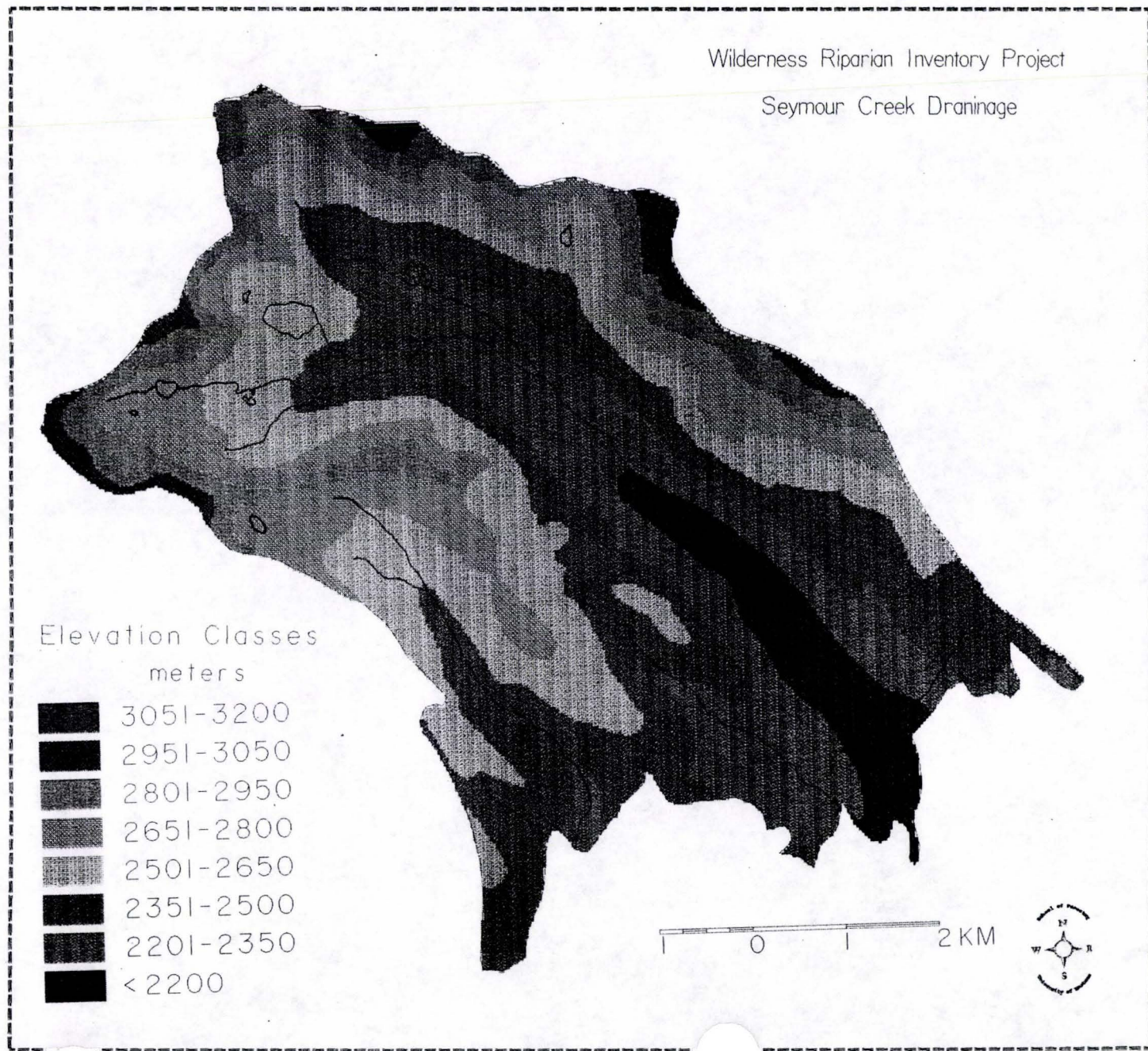


Figure 4. The Study Area Elevation Classes.

relationship of the understory plants to the overstory. An understanding of this relationship will be useful in the future during the analysis of digital imagery and model development. A stratified random sampling procedure was used to collect data for analysis. Sampling was completed at 32 sites and consisted of a transect 2 m by 100 m.

- 18) The location of each sample transect was digitized onto the hydrography vectors. I superimposed an oval over each transect to represent a polygonal feature on top of the linear feature. This step enabled the overlay of other data with the sample locations in the GIS.
- 19) I created a polygonal cover of the sample transects and updated the polygonal database with data on the associated stream order, stream gradient, elevation, and landform for each sample transect.

Results

The Seymour Creek study area encompasses 4,781 ha. The elevation of the study area ranges from 2,057 to 3,184 m, with a mean of 2,513 m and a standard deviation of 213 m. Seven landforms were identified in the study area (Table 1). Trough Walls covered the greatest area (Figure 5). Landforms with hydrography present are: cirque floors, cirque walls, trough walls, trough bottoms, and glaciated slopes. The trough bottoms and cirque floors had the greatest length of stream segments.

Table 1. Seymour Creek Landform summary data

LANDFORM	Total Area (ha)	polygon size (ha)		Reach	
		Min	Mean	Max	Lengths (m)
Glaciated Slopes	1101.6	50.94	157.37	235.17	2,532.22
Cirque Walls	876.15	41.31	438.08	834.84	1,016.43
Cirque Floors	797.04	19.35	79.7	117.54	16,062.80
Trough Walls	1250.82	20.88	96.22	307.98	5,323.16
Trough Bottoms	384.75	36.27	128.25	290.88	13,438.89
Mountain Slopes	319.14	80.91	106.38	145.98	0.00
Moraines	51.38				0.00
Total	4780.8	20.88	122.58	834.84	35,364.42

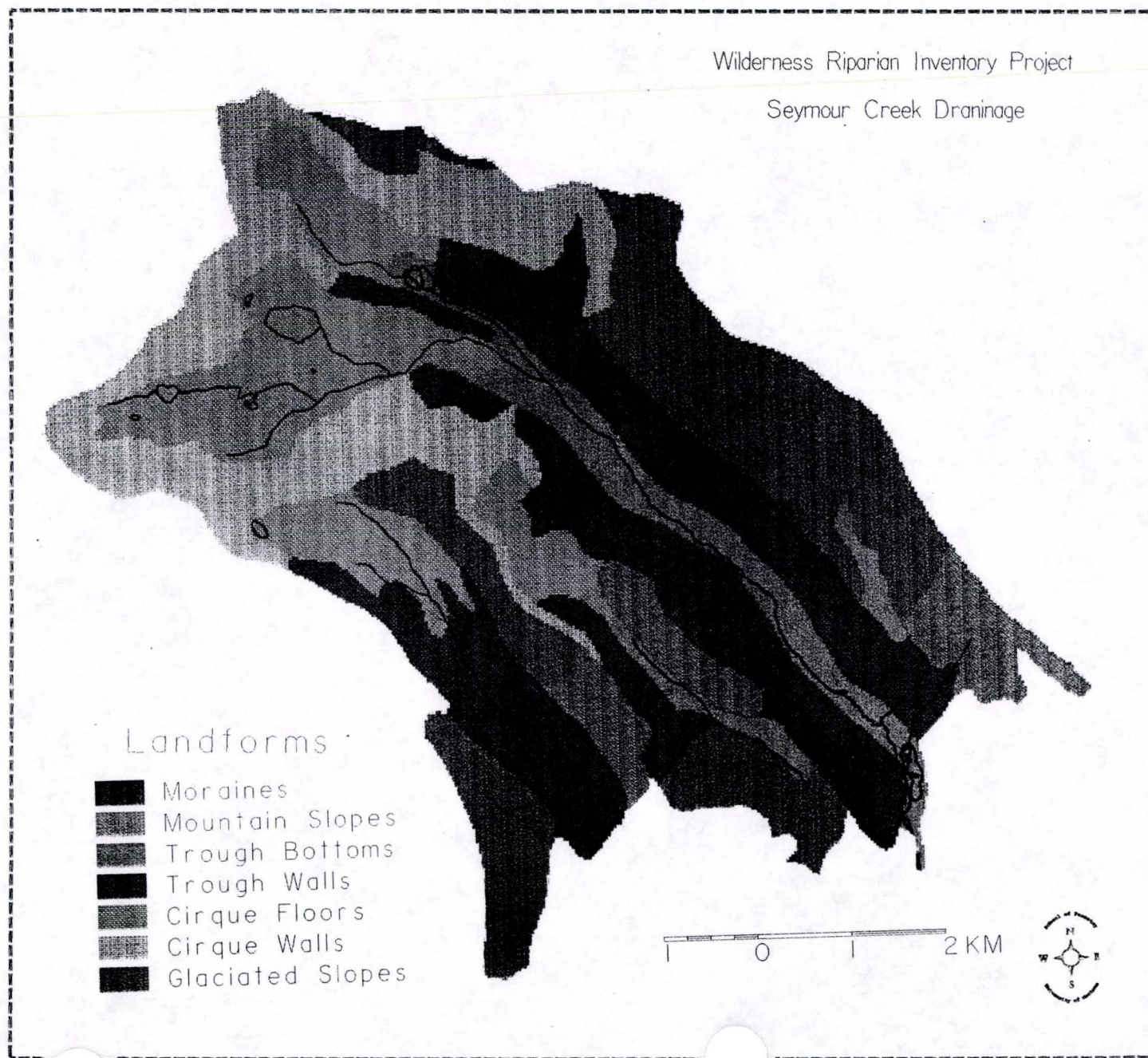


Figure 5. The Distribution of the Study Area Landforms.

The Networker module created 90 reach segments (Appendix A). In the hydrography database, each reach segment has a slope, length, elevation, and associated landform. These independent variables are not correlated (Table 2). The slope of the reach segments ranges from 0 to 17.34% (Table 3). The length of the reach segments ranges from 11.29 to 2,454.77 meters (Table 3).

Table 2. Correlation Matrix of Independent Variables.

	SLOPE	MEAN ELEV	LENGTH
SLOPE (%)	1.000		
MEAN ELEV (m)	0.108	1.000	
LENGTH (m)	0.383	0.250	1.000

Table 3. Summary Statistics for Stream Segments.

	SLOPE (%)	MEAN ELEV (M)	LENGTH (M)
N OF CASES	90	90	90
MINIMUM	0.000	2,060.940	11.290
MAXIMUM	17.340	2,737.250	2,454.770
MEAN	5.240	2,300.801	426.372
STD DEVIATION	3.470	207.650	458.338
STD ERROR	0.366	21.888	48.313

Discussion

There are four independent variables related to the stream segments, slope, elevation, length, and landform. The only variable that the 90 stream segments are correlated to is landform. The stream reaches are found primarily in the cirque floor and trough bottom landforms. This indicates that the use of geomorphology is a valid approach to the stratification of stream reaches. Analysis of the vegetation sample data is required to determine if there is any relationship between stream gradient, landform, and vegetative cover (Appendix B).

Significant problems were introduced in this initial work because of the lack of control that I had over the source of the digital data. There are currently few standards to control the format and procedures for exchanging data between agencies, groups, and platforms. Each agency or group has different objectives and needs in dealing with their digital data. As a result, each user tends to maintain the files in the format that works best for their purpose. That policy can create problems when sharing data. As I have demonstrated, there is almost always a method for working around these problems. However, the time involved and the errors that may be introduced make these efforts undesirable. Time, effort, and error can be reduced by transferring digital data in geographic coordinate systems in a standard format.

This work has built a foundation that will be useful in pursuing future work on developing a procedure for assessing the distribution and condition of wilderness riparian and wetland ecosystems. The next step would be to acquire digital images of the study area and test the ability of the imagery and GIS to quantify the relationships between stream gradient, landform, and vegetative structure.

References

- EPS. 1994. PAMAP, version 4.1. Essential Planning Systems, Victoria, British Columbia.
- Holdorf, H. and J. Donahue. 1990. Landform for Soil Surveys in the Northern Rockies. Montana Forest and Conservation Experiment Station, University of Montana. 26 p.

Appendix A. Stream Reach Segments sorted by % Slope (Stream Gradient)

TAGID ¹	ELEVATION (m)			LENGTH (m)	SLOPE (%)	LANDFORM ²	
	mean	minimum	maximum				
6	2101.17	2101.17	2101.17	11.75	0.00	16	16
56	2573.04	2573.00	2573.15	90.95	0.63	15	15
66	2088.60	2088.27	2088.81	55.40	1.04	18	18
55	2573.21	2573.06	2573.41	61.82	1.09	15	15
82	2330.16	2328.86	2331.25	129.26	1.17	18	18
13	2116.34	2112.96	2121.51	342.06	1.22	18	18
45	2733.79	2733.69	2734.15	20.55	1.67	15	15
67	2089.66	2088.75	2091.52	102.50	1.69	18	18
43	2732.45	2731.44	2733.69	270.70	1.82	15	15
81	2331.05	2328.86	2332.40	157.47	1.82	17	18
78	2104.04	2103.95	2104.29	21.05	1.96	18	18
65	2073.64	2071.91	2075.27	117.48	2.07	17	18
18	2176.68	2165.79	2191.13	694.73	2.12	18	18
70	2092.23	2091.52	2092.77	34.08	2.12	18	18
84	2334.01	2331.25	2335.81	206.51	2.16	18	18
17	2161.01	2156.17	2165.79	581.71	2.28	17	18
15	2137.79	2121.51	2151.28	1151.19	2.45	18	18
16	2153.90	2151.26	2156.17	496.91	2.48	16	18
77	2107.84	2106.91	2109.74	58.33	2.57	18	18
33	2113.47	2113.18	2113.86	13.35	2.58	18	18
37	2492.07	2491.74	2492.34	11.29	2.67	15	15
35	2572.25	2571.29	2573.52	317.60	2.71	15	15
39	2573.40	2573.00	2574.66	376.58	2.84	15	15
87	2337.08	2336.19	2337.55	85.59	2.87	18	18
88	2335.89	2334.84	2337.33	46.44	2.89	18	18
42	2737.25	2736.86	2737.64	15.20	2.92	14	14
85	2333.10	2330.37	2337.08	212.59	2.95	18	18
38	2492.86	2491.74	2493.98	52.84	3.12	15	15
86	2334.17	2331.25	2336.93	100.66	3.40	18	18
34	2114.07	2113.16	2115.16	163.06	3.46	18	18
59	2080.52	2073.40	2088.30	467.54	3.48	17	18
80	2095.06	2094.26	2095.75	31.19	3.59	18	18
64	2078.39	2075.27	2081.01	105.74	3.62	16	17
61	2095.64	2088.81	2102.85	251.70	3.63	18	18
83	2335.36	2331.53	2338.68	192.73	3.72	18	18
89	2337.91	2334.84	2339.24	165.13	3.76	18	18
63	2070.08	2063.83	2075.27	190.25	3.83	17	18
19	2207.71	2191.13	2221.42	785.79	3.86	18	18
28	2312.91	2294.55	2332.73	877.79	3.88	16	16

TAGID ¹	ELEVATION (m)			LENGTH (m)	SLOPE (%)	LANDFORM ²	
	mean	minimum	maximum				
48	2239.64	2221.42	2251.11	778.65	3.90	18	18
46	2295.64	2250.66	2328.86	1580.00	4.00	18	18
10	2109.63	2105.87	2112.96	270.75	4.02	18	18
79	2095.49	2094.26	2096.59	104.64	4.12	18	18
30	2060.94	2058.83	2064.47	211.91	4.20	18	18
74	2103.47	2102.85	2103.95	12.77	4.22	18	18
75	2093.52	2092.77	2094.26	18.96	4.24	18	18
36	2493.06	2492.34	2493.71	19.32	4.30	15	15
41	2733.32	2732.48	2736.86	156.51	4.35	14	15
44	2736.09	2734.15	2737.64	64.08	4.37	14	15
20	2334.48	2333.08	2337.33	328.48	4.51	18	18
51	2434.62	2393.37	2469.42	863.61	4.89	15	15
72	2109.73	2108.33	2110.56	38.29	4.94	18	18
31	2088.33	2086.48	2089.63	222.07	4.96	18	18
7	2105.83	2104.24	2106.91	169.97	4.99	18	18
9	2066.90	2063.88	2071.91	103.78	4.99	18	18
71	2107.33	2106.91	2108.33	18.67	5.02	18	18
24	2525.00	2520.01	2532.32	765.33	5.02	15	15
49	2378.15	2357.21	2393.37	576.68	5.14	15	15
2	2260.52	2252.22	2271.66	486.67	5.41	13	18
73	2104.59	2102.85	2105.47	67.84	5.45	18	18
47	2288.99	2250.66	2357.21	1350.79	5.65	15	18
58	2101.17	2088.30	2109.57	623.45	5.78	16	18
4	2328.48	2298.60	2358.75	573.37	6.35	18	18
69	2092.56	2090.88	2094.46	94.59	6.46	18	18
25	2435.70	2391.92	2490.18	1040.08	6.49	12	12
50	2428.80	2393.37	2473.86	619.18	6.62	15	15
27	2447.97	2399.65	2486.14	1345.30	6.95	15	16
90	2413.98	2337.33	2476.67	1311.02	7.01	15	18
76	2101.35	2095.75	2106.91	100.04	7.08	18	18
3	2291.18	2271.66	2304.34	661.18	7.38	12	18
53	2618.35	2573.06	2688.30	974.83	7.39	15	15
5	2384.67	2358.75	2418.53	510.98	7.41	18	18
54	2515.90	2469.42	2573.15	754.82	7.75	15	15
40	2732.23	2731.06	2734.50	183.48	7.94	15	15
26	2371.81	2332.73	2404.28	1277.11	7.96	16	16
52	2553.62	2469.42	2647.17	1229.70	8.58	15	15
60	2089.67	2075.21	2110.66	1020.24	8.70	18	18
29	2569.32	2486.14	2689.18	2454.77	9.11	15	16
32	2545.18	2543.52	2547.12	557.51	9.46	14	16
57	2107.30	2104.21	2112.89	368.43	9.72	18	18

TAGID ¹	ELEVATION (m)			LENGTH (m)	SLOPE (%)	LANDFORM ²	
	mean	minimum	maximum				
8	2083.67	2079.99	2085.49	104.34	9.97	16	16
1	2233.55	2197.93	2252.22	830.96	10.50	12	18
14	2377.99	2333.31	2403.71	453.62	11.13	16	21
62	2142.45	2109.74	2194.36	451.59	11.27	16	18
22	2496.22	2476.67	2525.30	223.13	11.36	14	15
68	2118.78	2105.03	2148.98	246.52	11.66	16	18
21	2708.51	2687.95	2767.38	1218.91	13.52	15	15
23	2515.12	2473.86	2532.32	1192.73	13.83	15	15
12	2262.55	2194.36	2333.31	476.71	16.07	16	16
11	2178.92	2148.98	2206.65	197.63	17.34	16	16

1. **Tagid** is a unique number assigned to each stream segment.

2. **Landform Codes** (note: each reach has two landform codes because the program treated this ordinal data as interval data and calculated a minimum, mean, and maximum value. Only the minimum and maximum values are reported here.)

12 = Glaciated Mountain Slopes

14 = Cirque Walls

15 = Cirque Floors

16 = Trough Walls

18 = Trough Bottoms

21 = Mountain Slopes

**Appendix B. Cover Type of Stream Segments with Associated Vegetation
Sample Plots Sorted by Stream Gradient.**

Tagid	Plot #	Cover Type	Landform	Stream Order	Stream Gradient (%)	Elevation (m)
13	58	non forest	Trough Bottom	3	1.22	2116
18	45	Spruce	Trough Bottom	3	2.12	2177
84	35	non forest	Trough Bottom	1	2.16	2334
17	49	Spruce	Trough Bottom	3	2.28	2161
15	52	LPP	Trough Bottom	3	2.45	2138
16	50	Mixed Spruce	Trough Bottom	3	2.48	2154
35	37/02	Fir	Trough Bottom	1	2.71	2572
90	30/02	Mixed Fir	Cirque Floor	1	2.84	2380
22	29/02	Mixed Larch	Cirque Floor	1	2.92	2530
90	30/05	Mixed Conifer	Cirque Floor	1	3.12	2430
63	65	non forest	Trough Bottom	5	3.83	2070
19	44/01	Mixed Spruce	Trough Bottom	3	3.86	2208
46	37/01	Fir	Trough Bottom	2	4.00	2296
30	66	non forest	Trough Bottom	5	4.20	2061
51	17/01	Spruce	Cirque Floor	2	4.89	2435
53	7	non forest	Cirque Floor	2	4.96	2600
49	28/04	Mixed Fir	Cirque Floor	3	5.14	2378
58	64/02	Mixed Spruce	Trough Bottom	4	5.78	2101
58	6403	Mixed LPP	Trough Bottom	4	5.78	2105
53	3	non forest	Cirque Floor	2	6.95	2690
90	30/01	Mixed Fir	Cirque Floor	1	7.01	2414
53	9	non forest	Cirque Floor	2	7.39	2618
54	11/01	Mixed WBP	Cirque Floor	2	7.75	2516
90	30/07	Mixed Fir	Cirque Floor	1	7.94	2465
53	5	Fir	Cirque Floor	2	9.11	2630
51	18	Mixed Spruce	Cirque Floor	2	9.46	2415
57	63	non forest	Trough Bottom	3	9.72	2107
22	29	Spruce	Cirque Floor	1	11.36	2496
17	47	Mixed Conifer	Trough Bottom	3	11.36	2165
68	61	non forest	Trough Walls	1	11.66	2119
21	1	non forest	Cirque Floor	1	13.52	2709
0	57	non forest	Trough Walls	1	16.51	2160

(note: plot #57 was associated with a stream segment that was not in the digital hydrography.)